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MULTI-YEAR PROCUREMENT AND
LEARNING CURVE EFFECTS

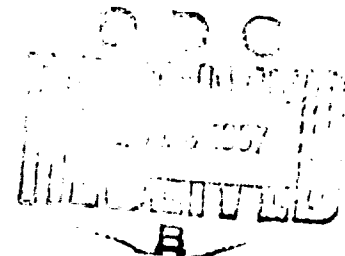
TASK 67-20

October 1967

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I. INTRODUCTION	
A. Study Objectives	1
B. ASPR Definition of MYP	1
C. Characteristics of MYP	2
D. MYP Cancellation Provisions	2
E. The Learning Curve Effect and Cancellation	4
II. ISSUES AND PROBLEMS	
A. The MYP Pricing Dilemma	5
B. The Learning Curve Effect	5
C. Learning Curves, Quantities and Cancellation Ceilings	12
D. Present Environment of MYP	14
E. Termination of Contracts	15
F. Cancellation Ceiling and Funding of Contracts	19
G. Applicable Procurement Situations	21
III. POSSIBLE SOLUTIONS	
A. Basic Considerations	23
B. Step-Bidding	24
C. Weighted Evaluation of Bids	25
D. Add Learning to Cancellation Clause	28
E. Treat Cancellation as a Termination for Convenience	29

TABLE OF CONTENTS (continued)

<u>Section</u>	<u>Page</u>
IV. CONCLUSIONS AND RECOMMENDATIONS	
A. ASPR Should be Revised to Provide for the Learning Effect in MYP	32
B. The Treatment of the Learning Effect and Start-up Costs Should be Combined .	32
C. The Learning Effect Should be Covered in Every MYP Contract	33
D. Realistic Cancellation Ceilings Cannot be Determined	33
E. MYP Cancellation Should be Treated - a Termination for Convenience	33

Appendices

I. Task Order -- Multi-Year Procurement-- Learning Curve Effect	
II. Cancellation Ceiling Requirements -- Effect of Learning Curves and Production Quantities	
III. Comparison of Loss Contract Reimbursement under Alternative of Adding Learning Effect to Cancellation and Treatment of Cancellation as Termination.	
IV. Proposed Revision of ASPR Clauses -- Treatment of Cancellation as Termination.	

I. INTRODUCTION

A. Study Objectives

The Task Order, Multi-Year Procurement--Learning Curve Effects, a copy of which is found in Appendix I of this report, requested LMI to analyze the effect of high learning curve applications in Multi-Year Procurements (MYP) and to recommend the optimum method to provide for protection of contractors in event of cancellation. LMI was to formulate details of proposed contract clauses, specific definitions, and potential application of the method recommended.

B. ASPR Definition of MYP

A discussion of the concept of MYP is a necessary introduction to the subject of this report. The ASPR definition of MYP is given in 1-322.1(a):

Multi-year procurement is a method for competitive contracting for known requirements for military supplies, in quantities and total cost not in excess of planned requirements for five years, set forth in, or in support of, the Department of Defense Five Year Force Structure and Financial Program, even though the total funds ultimately to be obligated by the contract are not available to the contracting officer at the time of entering into the contract. Under this method, contract quantities are budgeted for and financed in accordance with the program year for which each quantity is authorized . . . If award is made on the multi-year basis, funds are obligated only for the first year's quantity, with succeeding years' contract quantities funded annually thereafter. In the event funds are not made available to support one or more succeeding year's quantities,

cancellation is effected. The contractor is protected against loss resulting from cancellation by contract provisions allowing reimbursement of unrecovered nonrecurring costs included in prices for cancelled items.

C. Characteristics of MYP

The provision for reimbursement of unrecovered nonrecurring costs is one of two essential characteristics distinguishing MYP and the use of options--another technique for contracting for more than one program year's requirements (ASPR 1-1505). The other essential feature of MYP is the requirement of ASPR 1-322.2(b) (iv) that the unit prices of an item shall be the same for all program years. This requirement for "level-pricing" is one of the reasons for the provision concerning reimbursement of unrecovered nonrecurring costs in the event of cancellation of requirements for one or more program years under contract. If different prices could be quoted for the several program years, all nonrecurring costs could theoretically be included in the first year's price.

The requirement for "level-pricing" is also the root of the learning curve problem resulting in this study. If different prices could be quoted for the several program years, the declining unit costs normally experienced in production could be reflected in lower unit prices quoted for each successive program year.

D. MYP Cancellation Provisions

If the Government does not make funds available for a program year's quantities by a date specified in the contract, all remaining quantities under the MYP contract are cancelled. The cancellation of these quantities means that the contractor does

not recover in the unit prices the balance of the nonrecurring costs which, because of the "level-pricing" requirement, must, of necessity, be spread over all the MYP quantity. These "un-recovered nonrecurring costs" are reimbursed under paragraph (e) of the clause Cancellation of Items (Oct. 1966), in a sum not to exceed a cancellation ceiling amount specified in the contract:

The cancellation charge is intended to cover only expenses reasonably necessary for production which would have been equitably amortized in the unit prices for the entire quantity of the Multi-Year Procurement, but which, because of the cancellation, are therefore not so amortized. The cancellation charge shall be computed and claim therefore made as would be applicable under the "Termination for Convenience of the Government" clause of this contract. The claim may include reasonable preproduction and other nonrecurring costs, applicable to and which normally would be amortized in all items to be furnished under the multi-year requirements, such as plant rearrangement, special tooling, preproduction engineering, initial rework, initial spoilage, and pilot runs. The claim shall not include any amount;

- (i) for labor, materials, or other expenses incurred for production of the cancelled items;
- (ii) for any item or cost for which payment has already been made to the contractor; or
- (iii) for anticipated profit on the cancelled items, or on the costs included in the cancellation charge.¹

¹ASPR 1-322.5(b)

E. The Learning Curve Effect and Cancellation

The impact of the learning curve effect on costs and pricing of MYP contracts is developed in Part II of this report. In substance, the effect of learning is that the average unit costs of production decline as the quantity of units produced increases. The effect of cancellation is to abbreviate the production experience, thus causing higher average unit costs of production over the smaller quantity than was to be anticipated over the larger quantity.

The Task Order in Appendix I reflects the generally accepted position that the Cancellation of Items clause does not allow for reimbursement to reflect the higher average unit costs of production resulting from a reduction in quantities to be produced. There is considerable doubt that this position would be sustained if an appeal were taken to the Armed Services Board of Contract Appeals.¹ Nevertheless, many Government personnel and many industry representatives act on the premise that reimbursement could not be claimed. More significantly, even if the validity of the claim were to be ultimately sustained, it would be unlikely that the cancellation ceiling specified in a MYP contract would be large enough to reimburse the contractor for this claim and other claims for accepted nonrecurring costs.² In this connection, it should be noted that ASPR guidance to the contracting officer on establishing appropriate cancellation ceilings is completely silent on the consideration to be given to learning and its effect on production costs.³

¹This is discussed in Part II. E.

²This is discussed in Part II. C.

³ASPR 1-322.2(c)

II. ISSUES AND PROBLEMS

A. The MYP Pricing Dilemma

The MYP pricing dilemma is the central problem of MYP and the learning curve effect. It is the central problem because it portrays the effect of a situation in which the contractor cannot be assured of reimbursement of reasonable costs incurred in the performance of work for the Government.

Let us assume for the moment that the learning effect is not a proper claim under the clause Cancellation of Items; or, if perhaps a proper claim, that the cancellation ceiling amount is not large enough to provide for reimbursement. The pricing problem can be described with a hypothetical MYP situation: a three-year contract for a quantity of 100 units each year. We will also postulate a learning curve of 85 percent, with a first unit cost of \$10,000. A learning curve of 85 percent, with a first unit cost of \$10,000, develops an average unit cost of \$3408 for the total of 300 units and an average unit cost of \$4375 for first 100 units.¹

The contractor's dilemma is whether to price on the basis of the average cost of 300 units and chance cancellation at the end of the first year; or to price on the basis of the average of 100 units so that he will be made whole in the event of cancellation.

1. Price based on 300 units and contract cancelled at end of first year:

Contractor's cost (100 units @ \$4,375)	\$437,500
Contract payment (100 units @ \$3,408)	<u>340,800</u>
Contractor's loss	\$ 96,700

¹See Appendix II.

2. Price based on 100 units and contract not cancelled:

Contract payment (300 units @ \$4,375)	\$1,312,500
Contractor's cost (300 units @ \$3,408)	<u>1,022,400</u>
Over-recoupment by contractor	\$ 290,100

The dilemma is obvious. If the contractor bases his price on the expectation that there will be no cancellation, a cancellation will result in a very substantial loss situation. On the other hand, if the price is based on the desire to be whole in the event of cancellation, an equally substantial windfall profit will be obtained if the Government does not cancel the contract.¹

The contractor's dilemma is especially distressing because the possible loss situation is not determined by him. The decision whether the contract is to be cancelled or allowed to go to completion is solely the Government's, and will be based on the availability of funds and continuing requirements for the supplies.

The dilemma is particularly distressing to smaller companies which are less able to "insure" against risk situations on one or two particular contracts by spreading potential losses over a larger volume of other contracts. In addition, the alternative of bidding a higher price to protect against loss in event of cancellation is largely visionary in price competitive procurement situations.² The higher price is likely to be

¹The greater the learning effect anticipated in the pricing the greater will be the potential of loss and gain as a percentage of total contract price.

²ASFR 1-322.1(c)(ii) requires that there be reasonable expectation that there will be effective competition when MYP is used.

the losing price. Occasions can arise, however, when all competing bidders will attempt to protect themselves from cancellation loss and thereby cause the Government to pay a higher price than would have been necessary if the learning curve effect had been a part of the contract. Generally, the dilemma is whether the contractor will assume the risk of a significant loss in the event the Government cancels the contract or choose not to bid at all.

B. The Learning Curve Effect

This report is not the place for a treatise on the learning curve.¹ However, certain specific aspects of this phenomenon must be examined because they relate so closely to the MYF pricing problem.

The studies made of production costs incurred by airframe contractors during World War II are often cited as a milestone in the development of the learning curve theory. These studies disclosed that the average rate of improvement for all companies was 20 percent. In the parlance of the learning curve, this translates to an 80 percent learning curve reflecting the average production cost experience of the airframe industry. The curves experienced by individual companies in the above mentioned study varied considerably from this average. They ranged from curves of 65 percent to curves of 98 percent.² The clear import of these data was that there was no "standard," or "right" learning curve for the aircraft industry.

¹An excellent source for an introduction to the mechanics of the learning curve theory and technique is The Improvement Curve (Trainee's Manual TM 909-1), The Boeing Company, Wichita, Kansas.

²Sense Contract Audit Manual, par. F-101(b)

The fact that different companies experienced such widely different rates of learning was not due to differences in the intelligence level of their employees. The difference in learning curves is attributable to the fact that a variety of factors influence the curves in a particular plant. The Defense Contract Audit Manual lists eight distinct factors contributing to what is called "learning":¹

1. Job familiarization by the production workers, both through repetition of manufacturing operations and as a result of additional training.
2. Changes in product design which do not materially affect the product, but result in increased ease and speed of production.
3. Changes in tooling, machinery, and equipment which simplify or speed up the production process.
4. Improved production planning and scheduling, and improvements in production techniques and operational methods.
5. Improvements in shop organization, and in engineering coordination and liaison.
6. Improvements in the handling and flow of materials, and in the materials and parts supply systems, with an attendant reduction in lost time.
7. Increased specialization of workers through greater subdivision of the work and centralization of similar operations.
8. Increase proportion of skilled workers to semi-skilled workers and trainees.

Other students of the learning curve have enumerated seven preproduction factors and eight "during production" factors which influence the reduction in costs reflected by the learning curve:²

¹DCAM, par. F-101(d). See, also, the more extended discussion of some 11 factors at par. F-105(b).

²R. W. Conway and A. Schultz, Jr., "The Manufacturing Progress Function," (unpublished paper, Department of Industrial and Engineering Administration, Cornell University), pp. 10-12.

1. Production Factors

- a. Tooling - type of tooling used and degree of completion or development prior to production.
- b. Equipment and tool selection - volume for which production was planned.
- c. Product Design - extent to which manufacturability was considered and the degree of change required subsequently. Degree to which product design and manufacturing engineering were coordinated prior to initiation of production.
- d. Methods - the degree to which work methods in detail are pre-designed and the effort devoted to associated jig and fixture design, flow analysis, etc.
- e. State of the Art - relationship between the difficulty of the task and the ability of the organization to perform it.
- f. Magnitude of the design effort - time and effort devoted to the problem of pre-production manufacturing design, specifications, test, inspection, etc.
- g. Shop organization - including handling methods, pre-production training, skill, planning organization, etc.

2. During-Production Factors

- a. Tooling - changes during production, method of increasing capacity for increasing demand (replication or redesign or production method)
- b. Methods - changes during production, work simplification and similar programs, operator originated changes, method of capacity increase.
- c. Design changes - degree to which manufacturing and product designs are changed to allow minor economies, specification and inspection changes as experience is gained.
- d. Management - improved planning, scheduling and supervision to encourage progress, increase effectiveness, diminish delays and idle time.

- e. Volume changes - changes in rate or anticipated duration of production which affect other factors and decisions.
- f. Quality improvements - the gradual reduction of rework and repair operations, the reduction of scrap losses.
- g. Incentive pay plans - manner in which administered, when installed.
- h. Operator learning - degree to which operators decrease time utilized in execution of a specified task.

Most students of the learning curve insist on using another expression in lieu of "learning curve"--such as "improvement curve" or "progress curve"--because learning is only one factor, and not even the most significant factor:

Contrary to the opinion of many reporters it is believed that operator learning in the true sense of performance of a fixed task is of negligible importance in most manufacturing progress. However, the operator may contribute improvements in task method in some environments. Despite this, tooling, flow, and methods changes along with product design changes have been found much more significant. Such changes are usually the result of management and engineering effort rather than operator learning in any sense.¹

The problem of determining the "right" learning curve in a particular situation is also illustrated by the very broad and uncertain guidance available. One handbook states: "A curve ranging from 70 to 95 percent can normally be applied to production lines of most industries."² It goes on to formulate

¹Conway and Schultz, op.cit., p. 12.

²Department of the Army Field Manual (FM 38-33) Logistics Procurement Management Negotiation, January 1963, p. 169.

a set of relationships which, it states, are shown by prior study and application of learning curves:

<u>Percentage of Assembly Labor</u>	<u>Percentage of Machine Labor</u>	<u>Resulting Percentage Curve</u>
75	25	80
50	50	85
25	75	90

This table, and the earlier listing of many factors influencing the learning curve rate, illustrate the relationship between preproduction costs and learning curves. Paragraph (e) of the Cancellation of Items¹ clause lists several examples of costs which may be claimed in the event of cancellation, including plant rearrangement, special tooling, preproduction engineering, and pilot runs. The fact that different levels of expenditures on these efforts will result in different assembly-machining ratios on a particular job requires no elaboration.

A last point about learning is the extent to which a significant learning curve effect may be anticipated on various kinds of production-assembly work. The variety of factors influencing learning, both preproduction and during production factors, suggests that learning in some degree can be expected in every production-assembly activity. Conroy and Schultz, summarizing the findings of their study of a large variety of different production situations, state that "progress exists--in a greater degree, for longer periods of time, and for more products than would have been expected."²

¹ASPR 1-322.5(b).

²Op. cit., p. 41.

C. Learning Curves, Quantities and Cancellation Ceilings

The effect of learning on the risk now implicit in MYP contracting is a function of the steepness of the learning curve and the quantity to be produced.

With some assumptions on rates of learning and production quantities, we can calculate the cancellation ceiling amount and percentage of total contract price that would be required to make the contractor whole in the event of cancellation. Calculations using as examples four different learning curve rates and three different production levels are contained in Appendix II. These calculations illuminate the relationship between the learning curve, production quantities, and the resulting cancellation ceiling requirements.

- For example, with a learning curve of 75 percent, a cancellation ceiling of 15.5 percent would be required at the end of the first year of a contract for 30 units (10 units per year for 3 years). The cancellation ceiling that would be required for a contract for 900 units (300 units per year for 3 years) on the same learning curve would be 18.7 percent. The larger the production quantity, the higher the percentage required as the cancellation ceiling.

- A contract for 300 units (100 units per year for 3 years) with a learning curve of 75 percent would require a cancellation ceiling of 18.2 percent at the end of the first year. A contract for the same 300 units with a learning curve of 85 percent would require a cancellation ceiling of 9.5 percent at the end of the first year. The steeper the learning curve, the higher the percentage required as the cancellation ceiling.

The calculations in Appendix II assume that all costs will be affected by the learning curve and are erroneous at least to the extent that some material costs will not follow a learning curve. For example, raw material and standard purchased parts would not follow the curve. If level costs of this variety constituted a significant proportion of the total costs, the required cancellation ceiling percentages would be very much reduced.¹ On the other hand, subcontracted material would follow a learning curve--which might be even steeper than the curve anticipated by the prime contractor. The learning curve problem in MYP, therefore, reaches to subcontractor as well as prime contractors. Allowance for their learning effect problems would have to be made in any plan for solution of the prime contract situation.

The computed cancellation ceiling percentages disclosed in Appendix II would require a very substantial increase in cancellation ceiling provisions now used for MYP contracts.

¹ The effect of different degrees of level costs on first-year cancellation ceiling percentages is illustrated by numbers comparable to those developed on page 12:

<u>Quantity and curve</u>	<u>No Level Costs</u>	<u>.25 Level Costs</u>	<u>.50 Level Costs</u>
30 units -- 75% curve	15.5%	8.3%	4.3%
900 units -- 75% curve	18.7%	4.3%	1.7%
300 units -- 75% curve	18.2%	5.8%	2.5%
300 units -- 85% curve	9.5%	4.8%	2.4%

The average first-year ceilings now set on MYP contracts is about 4 percent.¹ This 4 percent is on contract price; and assuming a 10 percent profit objective, this would be equivalent to about 4.5 percent on costs.² The 4.5 percent number is approximately the number produced by a 92 percent learning curve. Furthermore, it reflects a 92 percent curve before any allowance for other nonrecurring costs, such as tooling and preproduction engineering, now included in the 4.5 percent number. If there were such a thing as an "average" learning curve of 80 percent, with no level costs, and assuming that 4.5 percent ceilings adequately cover other nonrecurring costs,³ cancellation ceilings approximately four times as large as the present ceilings would be required to cover learning in addition to the other costs.

D. Present Environment of MYP

Most of the MYP contracts are formally advertised contracts. Consequently, no data is available to show whether contractors have assumed the risk of loss in event of cancellation or have inflated the level price so that they would recover all their costs in the event of cancellation. While there is no data, the clear impression emerges from discussions with industry

¹Based on a study of 71 MYP contracts. See OSD(I&L) report, Department of Defense Procurement Management Review of Military Interdepartmental Procurement Requests (MIPRS), Two-Step Formal Advertising, and Multi-Year Procurement in the Army, Navy, Air Force, and Defense Supply Agency, June 1965, p. 11.

²The calculations in Appendix II are based on costs, with no allowance for a profit factor.

³There is some evidence that the ceilings now used are not large enough to cover the nonrecurring costs exclusive of learning. See LMI report, Multi-Year Procurement at the Subcontract Level, June 1967, p. 26.

personnel that contractors have generally assumed the risk and have bid prices on the presumption that there would not be any cancellation. This presumption has proven to be very sound to date. While we cannot be sure of the precise number of MYP contracts cancelled since no central record has been maintained, the best available evidence indicates that there has been only one cancellation since MYP was instituted in 1961. This is one out of an estimated total of some 200-250 MYP contracts.

Nevertheless, there is evidence that the failure of MYP to provide adequate protection in event of cancellation has operated to the Government's disadvantage. For example, the potential risk has impeded the use of MYP at the subcontract level.¹ For another example, two prime contractors advised that they will not bid on any contracts with MYP provisions for the very reason that they would ordinarily be in a loss position in the event of cancellation at the end of the first year and do not intend to accept such a potential liability.

The use of MYP has received increasing publicity, and OSD is encouraging more extensive use of MYP throughout the Services and in DSA. The wider use of MYP must necessarily result in increasing contractor concern with cancellation provisions. This concern will become severe if there should be any significant number of MYP cancellations.

E. Termination of Contracts

The problem of what happens when the Government decides that it no longer has a requirement for items under contract

¹ LMI report, Multi-Year Procurement at the Subcontractor Level, June 1967, pp. 24-25.

is not peculiar to MYP. Every Government contract has a provision for termination at the convenience of the Government. What is peculiar to MYP is the fact that more than one program year's requirements are contracted for, with later years' requirements to be funded out of monies not presently available and not formally "under contract" until funded.

The standard termination clause for fixed price contracts is Termination for Convenience of the Government (April 1966).¹ Paragraph (f) of this clause provides that determination of costs will be governed by the principles for consideration of costs set forth in ASPR XV, Part 2. ASPR 15-205.42, Termination Costs, is addressed directly to this subject.

Cost recovery under ASPR 15-205.42 is very broad. Paragraph (b) provides for recovery of costs continuing after termination; paragraph (d) provides for recovery of the loss of useful value of special tooling, special machinery and equipment; and paragraph (e) provides for recovery of rental costs under unexpired leases. Paragraph (c) is particularly pertinent to this study and provides, in part:

- (c) Initial costs, including starting load and preparatory costs, are allowable, subject to the following:
 - (1) Starting load costs are costs of a non-recurring nature arising in the early stages of production and not fully absorbed because of the termination. Such costs may include the cost of labor and material, and related overhead attributable to such factors as--

¹ASPR 8-701.

- (i) excessive spoilage resulting from inexperienced labor,
 - (ii) idle time and subnormal production occasioned by testing and changing methods of processing,
 - (iii) employee training, and
 - (iv) unfamiliarity or lack of experience with the product, materials, manufacturing processes and techniques.
- (2) Preparatory costs are costs incurred in preparing to perform the terminated contract, including costs of initial plant rearrangement and alterations, management and personnel organization, production planning and similar activities, but excluding special machinery and equipment and starting load costs.

The Armed Services Board of Contract Appeals has held, on at least two occasions, that the term "starting load costs," as used in ASPR 15-205.42(c), includes the learning curve effect. In these cases the Board decided that the contractor was entitled to recovery for higher unit costs than were anticipated in the contract price, either as a part of settlement expense or as an adjustment to the unit prices for the untermiated units.¹

It is the generally accepted position that a contractor is not now able to claim the same recovery for the learning curve effect in the event of cancellation of a MYP contract as he would be able to claim in event of termination of any other

¹Dunbar Kapple Inc., 57-2 BCA par. 1448, at p. 4878 et seq; Fairchild Stratos Corporation, 67-1 BCA par. 6225, at p. 28,799. The contractor obtained no recovery in the latter case because the Board found no reliance on the learning curve effect was contemplated in the original contract pricing. No cases involving MYP have been heard by the ASBCA.

kind of contract. The position is that it is simply not covered in the applicable clause: Cancellation of Items. However, a good case can be made for the proposition that the learning curve effect could be claimed under current MYP clauses; that the claim would be sustained by the ASBCA; and that the contractor would recover these costs, if the cancellation ceiling were large enough to permit recovery. The argument for the proposition that the learning curve effect is recoverable under the present MYP clauses is as follows:

1. The Cancellation of Items (Oct. 1966) provides for recovery of "preproduction and other nonrecurring costs." (Emphasis added.)

2. ASPR 15-205.42(c) states that "starting load costs" are costs of a nonrecurring nature.

3. The ASBCA has held in Dunbar Kapple and in Fairchild Stratos that the learning curve effect is part of starting load costs.

It seems more than likely that the learning curve effect is in fact now covered in the event of cancellation.¹ However, it is not likely to be of any benefit to a contractor whose cancellation ceiling is too low to support both this claim and the other accepted nonrecurring costs such as tooling, plant rearrangement, and preproduction engineering.

¹See also the statement in ASPR 1-322.1(b)(3) of cost savings and related advantages to be considered in applying MYP, several of which are related to the effects of the learning curve.

F. Cancellation Ceiling and Funding of Contracts

A provision in MYP contracts which allows contractors to claim reimbursement for the learning curve effect in event of cancellation will be effective only if the cancellation ceiling is large enough to embrace the learning effect and other nonrecurring costs.

As noted in the data of Appendix II and on pages 12-13, the learning curve effect can develop significantly large requirements for cancellation ceiling amounts as a percentage of contract price. Moreover, the difference in the requirement is significantly affected by only relatively small shifts in the learning curve rates. For example, a 2.5 to 3 percent ceiling, which would be sufficient at the end of the first year of a contract with an anticipated 95 percent curve, would have to be increased to 5 to 6 percent for an anticipated 90 percent curve. This, it must be emphasized again, is in addition to any ceiling amount to cover tooling and other nonrecurring costs. Since the cancellation ceiling requirements are so fluid, and the effect of too low ceilings is to pass undeserved risks to contractors, it would appear desirable to eliminate the special cancellation ceiling amount.

When MYP was first incorporated in ASPR, there was a requirement to commit funds equal to the applicable cancellation ceiling.¹ The effect of this was to introduce a note of conservatism in setting cancellation ceilings to minimize commitment of funds.² On 1 October 1966 (ASPR Rev. 19), the ASPR

¹ASPR 1-322.2(e), Rev. 3, 15 November 1963.

²LMI report, Implementation Status -- Multi-Year Procurement, February 1965, pp. 61 et seq.

policy was revised to provide that contingent liabilities for cancellation charges would be carried as outstanding commitments in accordance with DoD Comptroller regulations. These regulations authorized "pooling" of risks when it was likely that the full liability would never be incurred on all the contracts. As a consequence, commitment of funds was no longer tied directly to cancellation ceilings in particular contracts. In the consideration of the 1968 DoD Appropriation Bill in the House of Representatives, the process was carried to its logical conclusion. The Committee on Appropriations recommended deletion of budget requests to cover "termination charges" stating that the Government was a self-insurer, that MYP had "proved itself as a proper and reliable means of procurement," and that the Committee would cooperate with DoD in making funds available later if termination charges should be required.¹

The present "pooling" arrangements for cancellation ceilings suggest that it should be possible to use higher ceilings for MYP contracts so as to allow for learning curve consideration without disturbing the financial planning of DoD. The legislative history of the 1968 DoD Appropriation Bill suggests that this supposition is a fact and that there is no reason why specific ceilings which are lower than the whole contract amount should be developed for MYP contracts.²

¹U.S. Congress, House, Committee on Appropriations, Department of Defense Appropriation Bill, 1968, 90th Cong., 1st Sess., 1967, H. Rept. 349 to accompany H.R. 10738, pp. 40-41.

²See Appendix III, para. A. for proposed revision of the ASPR clause to effectuate this plan.

G. Applicable Procurement Situations

The weight of evidence suggests that there is an effect of learning on costs in every production contract situation with the possible theoretical exception of very highly automated production lines. This is especially true when one considers the management efforts during production which have been found to influence unit cost trends. It follows, then, that the need for adding consideration of the learning effect applies to all MYP contracts.

The learning curve used by the contractor in pricing the bid originally, if indeed any was used, is not directly pertinent at the time of cancellation. The contractor may have modified his intended approach to production and incurred higher preproduction costs with corresponding anticipation of a more shallow learning curve. Actual costs incurred up to the point of cancellation may have demonstrated that the anticipated learning could not be achieved, or that even better learning would be achieved. The cancellation should not have the effect of either bailing the contractor out of trouble or of denying him the advantages which would have accrued had the contract been completed. The import of these propositions is that the learning effect which must be considered is not the one contemplated in the bidding but, rather, the one actually experienced in production.

The fact that the learning curve used by the contractor in the original pricing of the contract is not pertinent in the proper settlement of cancellation removes any advantage which might be supposed to be found in considering the learning effect only in negotiated procurements. The problem of

the learning curve effect is found on cancellation and the parties must look to the history and situation at that time. Limiting consideration of this problem to only negotiated MYP contracts would not be any more valid than eliminating consideration of learning in termination of all advertised procurements. The absence of original pricing information has not prevented equitable resolution of problems caused by terminating ordinary types of advertised contracts.

III. POSSIBLE SOLUTIONS

A. Basic Considerations

There are certain general observations which must be considered in any solution of the problem of the learning curve effect in MYP.

1. Cancellation is Not a Significant Problem

The experience with MYP shows that cancellation is an unlikely event. Cancellation is not a major problem--the inequity of the results in the event of cancellation is the problem. Procedures which might burden the auditor or the ACO in the (unlikely) event of cancellation are, therefore, preferable to procedures which would burden the placing of the MYP contract.

2. Simple Bid and Evaluation Procedures are Needed

MYP is and will continue to be primarily applied in formal advertising processes. Simple procedures must be maintained in the interest of both the Government and industry. In this same context, radical changes in the present MYP processes are less desirable than small, evolutionary adjustments since much effort has been devoted to indoctrinating both Government and industry personnel in the established procedures.

3. Award Should be Made to Low Bidder for MYP Quantity

The unlikely event of cancellation should not be given such consideration that the principal objective of MYP is obscured:

The principal objective of the multi-year procedure is to generate realistic competition by minimizing competitive disadvantage and by increasing contractor interest in participating in procurements which involve high startup costs and make-ready expense and which also may require substantial capital investment by contractors for expansion of their facilities.¹

B. Step-Bidding

The most obvious solution for the learning curve effect problem is to eliminate the requirement for level pricing over all of the program years of the MYP contract. The effect of the learning curve could then be reflected in the unit prices quoted for each separate program year. Initial costs, such as tooling and preproduction engineering, could be amortized in the price quoted for the first program year.

In this plan, bid evaluation would be based on multiplying the total units in each program year by the unit price bid for that year. The total bid would be the addition of the products of the calculations for each program year. An example of this plan follows:

Program Year	<u>Bid A</u>			<u>Bid B</u>	
	<u>Qty.</u>	<u>Unit</u>	<u>Total</u>	<u>Unit</u>	<u>Total</u>
1	100	\$100	\$10,000	\$252	\$25,200
2	100	80	8,000	1	100
3	100	75	<u>7,500</u>	1	<u>100</u>
TOTAL			\$25,500		\$25,400

The low bidder is Bid B, which would get the award.

¹ASPR 1-322.1(b)(2).

The example illustrates a fatal defect in this plan. The bidder is invited to "game" his bid. Having decided what the total bid price should be, the bidder may elect to load the first program year bid and bid only a nominal price for the following program years. One result is that the bidder will enjoy a windfall profit if the Government happens to cancel the contract. Another result is that the bidder can make it effectively impossible for the Government to cancel the quantities specified for later years, no matter what change there may have been in the requirements. The scrap or salvage value of the quantities specified for the later years could very well exceed the price to be paid for these units.

It would theoretically be possible to manage this situation by establishing limits on the bid prices for each year which could not be exceeded by any bidder. For example, a condition of the IFB might specify that the unit price bid for the first program year could not exceed twice the price bid for the third program year. This would only limit the problem, and not control it. The bidder would still have reason to game his bid to the maximum permissible extent. If the negotiator were to try to set reasonably accurate limits, he would have to make estimates of start-up costs and the expected learning curve as a basis for these calculations. He would not have available to him the data he would need to set the proper limits. Lastly, bid preparation would be more complicated, with many additional possibilities for erroneous calculations.

C. Weighted Evaluation of Bids

The basic defect of step-bidding is that there is no penalty on bidders for the loading of the bid prices in event of cancellation. The obvious answer for this problem would be to

include the bid prices for all program years in the evaluation, weighting the bids to discourage arbitrary gaming of prices in contemplation of a possible cancellation. This can be done by having the bidders submit unit prices for the cumulative quantity through each of the successive program years, the unit price bid to be the prices paid in the event of cancellation at the end of the stated program years. An example of this plan follows:

Program Year	Evaluation Factors	<u>Bid A</u>		<u>Bid B</u>	
		Cum. Unit Bid Price	Evaluation Bid	Cum. Unit Bid Price	Evaluation Bid
1	.10	\$100.00	\$10.00	\$90.00	\$ 9.00
2	.15	85.00	12.75	80.00	12.00
3	.75	75.00	<u>56.25</u>	76.00	<u>57.00</u>
Evaluated Bid Total:			\$79.00		\$78.00

This particular example, and the specific evaluation factors were chosen to illustrate some important defects in any plan for weighted bid evaluation in MYP, using arbitrarily derived evaluation factors.

- Bid B (with a unit price of \$76) is the lowest evaluated bid and would receive the award, in spite of the fact that bid A offers the lowest unit price (\$75) for the MYP quantity which the Government expects to procure.
- The bidder with high start-up costs (tooling, etc.) and the bidder with a steep learning curve are burdened. These bidders have a higher proportion of their costs booked in the first and early program years which must be reflected in the prices bid in these years. The higher

the start-up costs and the steeper the learning, the more they are burdened by a weighted evaluation plan even though their unit prices for the whole MYP quantity may be lower. MYP is intended to encourage competition by new sources, but weighted evaluation plans "discriminate" against new sources in favor of established sources.

- The selection of the evaluation factors has an uncertain rationale. The weighting on the early program years must be high to discourage gaming, but the higher they are the more likely it is that the award may not go to the bidder with the lowest bid for the whole MYP quantity.
- There is some question whether the use of arbitrary evaluation factors would be sustained by the Comptroller General. In one decision, B-159750, dated 11 January 1967, he criticized a cost factor which he found "inherently unrealistic" and "too hypothetical and speculative to serve as an evaluation factor."

This method of evaluation of MYP contract bids would be very suitable if experience with MYP disclosed a statistically significant probability of cancellation. In this unfortunate circumstance, evaluation factors reflecting the probability of cancellation in each program year of the MYP period would be based on actual experience. There would be sound data to support the evaluation factors used, representing the best available estimate of the probability of a cancellation of a particular procurement. The lowest evaluated bid would represent the best price to the Government, reasonable and proper consideration being given to the probability of cancellation. As noted earlier, however, the available records disclose only one cancellation of an estimated total of 200-250 MYP contracts awarded to-date.

D. Add Learning to Cancellation Clause

The effect of learning can also be considered by specifically allowing the learning curve effect in cost recovery in the event of cancellation, and by providing a ceiling high enough to admit recovery of all adjustments which the Government intends to be recovered. Since the effect of cancellation is to leave the contractor stranded on the high part of the production cost curve, the inequities would be resolved if the contractor obtained the difference between the higher average unit costs incurred on the smaller quantity and the lower average unit costs which would have been incurred on the whole quantity. The remedy, then, is to permit the contractor to claim this difference.

As noted earlier, the learning effect which must be considered is the curve actually experienced in production under the cancelled contract. The objective is to disturb the contractor's position (good or bad) as little as possible, but to compensate him for the lost opportunity to balance higher unit production costs in the early period with lower unit costs in a later period. The contractor would be properly compensated in the event of cancellation if he received:

1. The unit price set forth in the contract for the units delivered, as is now done in MYP.
2. The unamortized portion of the audit-verified start-up costs ("preproduction and other nonrecurring costs"), as is now done in MYP.
3. The difference between (a) the average unit production cost incurred on the quantity produced; and (b), the average unit production cost which the contractor

can demonstrate was reasonably anticipated on the whole MYP quantity if there had not been a cancellation.

An example illustrating this alternative is contained in Appendix III. D. The example demonstrates that in this alternative the contractor will suffer a proportionate part of any loss he might expect, and enjoy a proportionate part of any gain he might expect if the contract had not been cancelled.

The objective of adding the learning effect to cancellation could be achieved by inserting on line 10 of paragraph (e) of the clause Cancellation of Items (Oct. 1966):

The claim may also include an amount for the higher average unit production costs demonstrably resulting from the cancellation.

The provision suggested would place on the contractor the same burden of proof to support any claim for an adjustment on account of the learning effect as he now has in any ordinary termination process.¹

E. Treat Cancellation as a Termination for Convenience

The addition of the learning effect to the present cancellation provisions of MYP goes much of the way to an ultimate solution--treating cancellation as any other termination for convenience of the Government. This would be especially true if the MYP contract amount were used as the ceiling of liability in the event of cancellation. The costs that would then be specifically allowable in termination, but not specifically

¹See Fairchild Stratos Corporation, 67-1 BCA par. 6225.

covered in cancellation of MYP contracts, would be recovery of the loss of useful value of special machinery and equipment and recovery of rental costs under unexpired leases.¹ In addition, under the termination process the contractor could claim a profit on all unamortized costs including the learning effect.

There is some evidence that the use of MYP is impeded by the fact that there is no recovery for any part of the unamortized cost of equipment in the event of cancellation.² There is also the question whether a contractor should receive any less "equity" in treatment of costs under a cancelled MYP contract than he would receive under a termination of any other contract.

A different aspect of equity suggests an advantage implicit in the alternative of treating cancellation as a termination compared with the alternative of adding the learning effect to the present cancellation provisions of MYP. In a loss contract situation, the contractor would be paid more under cancellation than he would under termination. This results from the adjustment under the termination provisions to reflect the indicated rate of loss on the contract.³ In any situation other than a

¹ASPR 15-215-42 (d) and (e).

²LVI report, Multi-year Procurement at the Subcontractor Level, June 1967 p. 26.

³See Appendix III. G. The difference arises from the fact that in termination settlement the adjustment for loss reflects the indicated rate of loss over the whole contract and takes into account any projected learning effect. Consequently, the dollar adjustment is greater in the first year(s) because a greater proportion of total costs are incurred in those years. In cancellation, the compensation of the contractor would reflect an adjustment for loss in the same ratio as the quantity of units not cancelled to the total units, and assumes a level unit cost throughout the contract.

loss contract, the contractor would be treated the same under both alternatives. While a contractor should not suffer any disadvantage in cancellation compared with termination, it would seem equally desirable that he enjoy no advantage.

If the cancellation provisions of MYP contracts were revised to treat cancellation as equivalent to termination, costs of labor and materials incurred for production of the cancelled items should continue to be specifically excluded from the contractor's claim.¹ The contractor must not be permitted to claim costs incurred in anticipation of future program years' requirements until the Contracting Officer has confirmed these requirements and the required funds are available. This is central to the MYP theory and intent.

¹See Appendix IV for ASPR revisions which would be required if cancellation were to be treated as a termination for convenience.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. ASPR Should be Revised to Provide for the Learning Effect in MYP

Bidders should not be required to bid under conditions which postulate either an extraordinary profit or an unanticipated loss, depending solely on the action of the Government.

Whether or not the contractor might claim consideration of the learning curve effect under the present MYP contract clauses, there is a need for revision of ASPR. First, to remove any doubt of the intent to provide reimbursement in event of cancellation. Second, to ensure that cancellation ceiling amounts will be established with a view to the substantial adjustment that may be required to compensate for the effect of learning on level unit prices.

B. The Treatment of the Learning Effect and Start-up Costs Should be Combined

There is a direct relationship between the learning curve and costs incurred for tooling, preproduction engineering and other accepted preproduction activities. The Government should not influence the contractor's approach to production economy. Low start-up costs combined with a steep learning curve are neither more preferred, nor evidence of better (or worse) management, than would be high start-up costs combined with a shallow learning curve. The objective of the lowest price to the Government for the MYP requirement may be reached by either path. Ceiling amounts on either of these costs separately from the other are not desirable.

C. The Learning Effect Should be Covered in Every MYP Contract

The effect of the learning curve on production costs can be expected in any production effort. Provision for its consideration in event of cancellation should, therefore, be made in every MYP contract.

D. Realistic Cancellation Ceilings Cannot be Determined. The MYP Contract Amount Should be the Ceiling

Cancellation ceilings which are set too low do not provide adequate protection to contractors. The result of too low ceilings would be to confront the contractor with the same pricing dilemma as he now has in the apparent absence of consideration for the learning curve effect.

Cancellation ceiling requirements are affected by start-up costs and the learning curve. These are peculiar to each contractor, and to each procurement. There is no simple way to calculate any appropriate ceiling amount. Consequently, the MYP contract price should be treated as the ceiling liability of the Government. In any event, the contractor will be reimbursed only for those costs which are determined by audit and negotiation to be due him in the event of cancellation.

E. MYP Cancellation Should be Treated as a Termination for Convenience

The best solution for the problem of the learning curve effect in MYP is to revise the Cancellation of Items clause to make cancellation equivalent to termination for convenience. The broader coverage of costs in termination, extending beyond the learning curve effect, would enhance the usefulness of MYP.

C O P Y

APPENDIX I

ASSISTANT SECRETARY OF DEFENSE
Washington, D. C

Installations and Logistics

DATE: 23 May 1967

TASK ORDER SD-271-73
(TASK 67-20)

1. Pursuant to Articles I and III of the Department of Defense Contract No. SD-271 with the Logistics Management Institute, the Institute is requested to undertake the following task:

A. TITLE: Multi-Year Procurement - Learning Curve Effects

B. BACKGROUND: Current ASPR requirements do not provide for contractor recoupment, in the event of cancellation, of unrealized savings that result from learning curve phenomena, and for which the Government has already received benefits in the form of lower prices for delivered items. Since current procedures also specify identical unit prices throughout the multi-year period, it is evident that contractors could easily be in a loss position in fulfilling contract commitments, even after payment of cancellation charges for non-recurring start-up costs, if the learning curve effect exists for the product in question. For these reasons, contractors may refuse to quote or may include a factor in price to guard against serious financial loss in event of cancellation. Neither of these potential results is in the Government's interest. It is highly desirable, therefore, in order to realize maximum benefits from use of MYP, that a realistic and workable means be found to provide maximum assurance to contractors of recovery of unrealized learning curve-savings where the learning curve phenomena is applicable.

C. SCOPE OF WORK: To meet the objectives of this task, it is necessary to analyze in detail the effect of high learning curve applications in multi-year procurements, including competitive (advertised and negotiated) and non-competitive types that may be undertaken on an approved deviation basis. The feasibility of various means of providing for contractor recovery of unrealized learning curve savings will be studied. A recommendation will be presented of the optimum method of providing for contractor protection in the event of cancellation as well

C O P Y

APPENDIX I

page 2

as realization by the Government of savings due to learning curve effects in Multi-Year Procurements. Details as to contract clauses, specific definitions, and the potential application of the method recommended will also be formulated.

2. SCHEDULE: This task will be completed and a final report will be submitted by 30 November 1967.

/S/ PAUL R. IGNATIUS

ACCEPTED /S/ BARRY J. SHILLITO

DATE May 23, 1967

CANCELLATION CEILING REQUIREMENTS
EFFECT OF LEARNING CURVES AND PRODUCTION QUANTITIES
(First Unit Cost = \$10,000)

LEARNING CURVE ANNUAL PRODUCTION RATE (Hypothetical MYP Contract for Three Years)	65%			75%		
	10-10-10	100-100-100	300-300-300	10-10-10	100-100-100	300-300-300
CUMULATIVE TOTAL COST:						
1st Year	\$ 43,410	130,340	208,060	55,890	241,790	469,430
2nd Year	\$ 61,950	175,540	276,660	88,280	368,010	709,670
3rd Year	\$ 75,400	208,060	325,990	114,460	469,430	902,630
CUMULATIVE UNIT COST:						
1st Year	\$ 4,341	1,303	694	5,589	2,418	1,565
2nd Year	\$ 3,098	878	461	4,414	1,840	1,183
3rd Year	\$ 2,513	694	362	3,815	1,565	1,003
REQUIRED CANCELLATION CEILING - 1st YEAR						
Costs Incurred	\$ 43,410	130,340	208,060	55,890	241,790	469,430
Payments Received	\$ 25,130	69,400	108,600	38,150	156,500	300,900
Loss	\$ 18,280	60,940	99,460	17,740	85,290	168,530
Loss as Percent of 3rd Year Cumulative Total Cost	24.2	29.3	30.5	15.5	18.2	18.7
REQUIRED CANCELLATION CEILING - 2nd YEAR						
Costs Incurred	\$ 61,950	175,540	276,660	88,280	368,010	709,670
Payments Received	\$ 50,260	138,800	217,200	76,300	313,000	601,800
Loss	\$ 11,690	36,740	59,460	11,980	55,010	107,870
Loss as Percent of 3rd Year Cumulative Total Cost	15.5	17.7	18.2	10.5	11.7	12.0

A

APPENDIX II

CANCELLATION CEILING REQUIREMENTS

LEARNING CURVES AND PRODUCTION QUANTITIES

(First Unit Cost = \$10,000)

75%			85%			95%		
10-10	100-100-100	300-300-300	10-10-10	100-100-100	300-300-300	10-10-10	100-100-100	300-300-300
55,890	241,790	469,430	71,160	437,540	1,022,300	89,540	765,860	2,121,770
38,280	368,010	709,670	124,020	747,890	1,742,310	171,300	1,456,930	4,033,420
14,460	469,430	902,630	170,910	1,022,300	2,378,810	250,030	2,121,770	5,872,390
5,589	2,418	1,565	7,116	4,375	3,408	8,954	7,659	7,073
4,414	1,840	1,183	6,201	3,739	2,904	8,565	7,285	6,722
3,315	1,565	1,003	5,697	3,408	2,643	8,334	7,073	6,525
55,890	241,790	469,430	71,160	437,540	1,022,300	89,540	765,860	2,121,770
38,150	156,500	300,900	56,970	340,800	792,900	83,340	707,300	1,957,500
17,740	85,290	168,530	14,190	96,740	229,400	6,200	58,560	164,270
15.5	18.2	18.7	8.3	9.5	9.6	2.5	2.8	2.8
88,280	368,010	709,670	124,020	747,890	1,742,310	171,300	1,456,930	4,033,420
76,300	313,000	601,800	113,940	681,600	1,585,800	166,680	1,414,600	3,915,000
11,980	85,010	107,870	10,080	66,290	156,510	4,620	42,330	118,420
10.5	11.7	12.0	5.9	6.5	6.6	1.8	2.0	2.0

B

APPENDIX III

COMPARISON OF LOSS CONTRACT REIMBURSEMENT UNDER ALTERNATIVES OF ADDING LEARNING EFFECT TO CANCELLATION AND TREATMENT OF CANCEL- LATION AS TERMINATION.

A. INTRODUCTION

The assumed facts for this illustration are:

- (1) A three-year MYP contracts for 100 units each year.
Cancellation at end of first year.
- (2) Contractor's bid based on a 75 percent learning
curve with a first unit cost of \$10,000; tooling
estimated at \$30,000.
- (3) Actual costs experienced an 85 percent learning curve
with a first unit cost of \$10,000; tooling cost
\$60,000.

B. COST DATA (See Appendix II)

(1) Bid

The contract price for 300 units on 75 percent curve:

Production Costs	\$469,430
Tooling	<u>30,000</u>

Total	\$499,430
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Unit Price	$\frac{\$499,430}{300}$	=	\$1,664.80
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(2) Incurred Costs

Average unit cost on 85 percent curve:

100 units	\$4,375
300 units	\$3,408

Total production costs on 85 percent curve:

100 Units	\$437,540	
Tooling	<u>60,000</u>	
Total		\$497,540
300 Units	\$1,022,300	
Tooling	<u>60,000</u>	
Total		\$1,082,300

C. CONTRACTOR'S SITUATION IF NO CANCELLATION

Contractor's Costs

Production costs	\$1,022,300	
Tooling	<u>60,000</u>	
Total Costs		\$1,082,300
Contract payment		<u>499,430</u>
Loss		<u>\$ 582,870</u>
Loss rate	$\frac{\$582,870}{1,082,300} = 53.85 \text{ percent}$	

D. ADJUSTMENT FOR LEARNING CURVE EFFECT IN CANCELLATION

Contract price (100 @ \$1,664.80)	\$166,480
Adjustment for learning effect	
100 (\$4,375-3,408)	96,700
Unamortized tooling	<u>40,000</u>
Total payments	\$303,180

E. TERMINATION SETTLEMENT -- TOTAL COST BASIS

Costs incurred

Production costs (100 @ \$4,375)	\$437,500
Tooling	<u>60,000</u>
Total	\$497,500
Less loss rate (.5385)	<u>267,904</u>
Total settlement	\$229,596*

* Difference due to rounding.

F. TERMINATION SETTLEMENT -- INVENTORY BASIS

Contract price (100 @ \$1664.80)		\$166,480
Claim for learning effect		
100(\$4375-3408)	\$96,700	
Claim for unamortized		
tooling	<u>40,000</u>	
Total	\$136,700	
Less loss rate (.5385)	<u>73,613</u>	
		<u>63,087</u>
Total settlement		\$229,567*

*Difference due to rounding.

G. SUMMARY

The adjustment for the indicated rate of loss in termination (paragraph E and F) reduces the contractor's claim for the learning effect and the unamortized tooling costs. If the cancellation settlement were by termination, the contractor's loss in this hypothetical case would be \$267,900 (\$497,500-\$229,600). If the settlement were by reimbursing the contractor for the lost opportunity to benefit from the learning effect, the contractor's loss would be \$194,300 (\$497,500-\$303,200); which is one-third of the total expected loss of \$582,870 had the contract not been cancelled (paragraph C).

APPENDIX IV

PROPOSED REVISION OF ASPR CLAUSES--TREATMENT OF CANCELLATION AS TERMINATION

A. Elimination of Lower Cancellation Ceiling Amounts

This would require revision of paragraph (e) of the clause Limitation of Price and Contractor Obligations (Oct. 1966) in ASPR 1-322.5(a), as follows:

(e) In the event of termination pursuant to the "Termination for Convenience of the Government" clause of this contract, the terms "total contract price" as used in that clause refers to the amount anticipated for performance of all Program Years of this contract. The term "work under the contract" as used in that clause refers to the work under Program Year requirements for which funds have been made available. In the event of termination for default, the Government's rights under this contract shall apply to the entire multi-year requirements.

B. Cancellation as Termination

This would require revision of paragraphs (c), (d), and (e) of the clause Cancellation of Items (Oct. 1966) in ASPR 1-322.5(b), as follows:

(c) Except for termination pursuant to the "Default" clause, any reduction by the Contracting Officer in the quantities called for under this contract shall be considered a termination in accordance with the "Termination for Convenience of the Government" clause of this contract.

(d) In the event of cancellation pursuant to this clause, the Contractor will be paid, as consideration therefore, a cancellation charge which shall be computed and claim therefor made as would be applicable under the "Termination for Convenience of the Government" clause of this contract; provided, however, the claim shall not include any amount;

- (1) for labor, materials, and related expenses incurred only for production of the cancelled items;
- (ii) for any item or cost for which payment has already been made to the Contractor; or
- (iii) for anticipated profit on the cancelled items.